IN3OTD's web site

...under perpetual construction.

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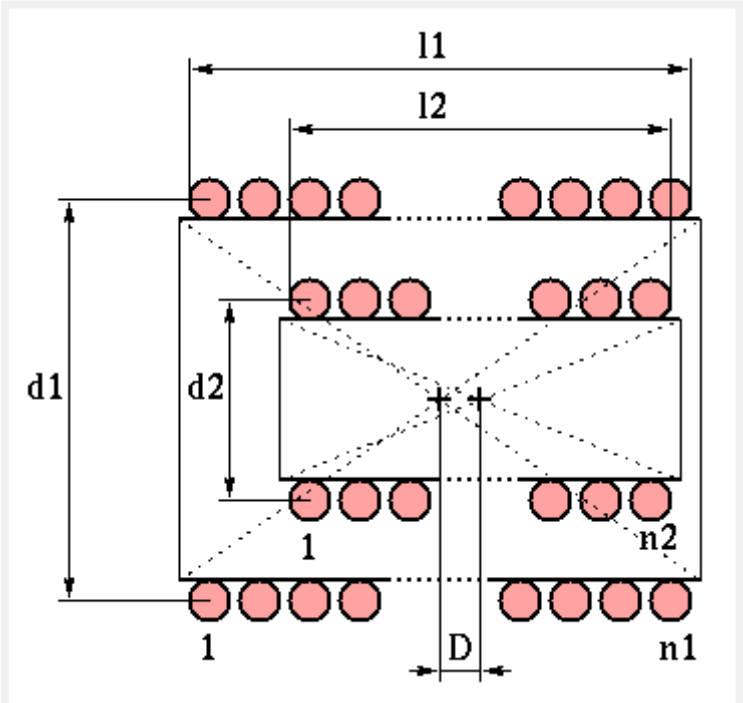
Variometer Design

A variometer consists usually of two coaxial coils, connected in series, where the coils relative position can be varied in some way. If L_1 and L_2 are the self-inductances of the first and second coil and L_m is the mutual inductance between the two, the total inductance can be written as $L_{tot}=L_1+L_2\pm2L_m$. The mutual inductance is defined as the flux linked by the turns of an inductance when the other carries a unit current; this of course depends not only on the coil length and diameter but also on their relative position.
For two coaxial coils, like the ones in the picture, the mutual inductance is at maximum when they are also *concentrical*, i.e. $D=0$.
If the two concentrical coils are rotated, so that their axes are not parallel any more, the mutual inductance decreases, reaching zero (almost) when the angle is $90°$. Continuing the rotation beyond $90°$ the mutual inductance increases again, but this time **with the opposite sign**. So, according to the above formula, rotating a coil $180°$ gives a variation of the total inductance of $4L_m$.

If the two coaxial coils are moved along their axis instead ($D<>0$), the mutual inductance decreases, eventually reaching zero at infinity, but does not change sign. This means that there is less variation in the total inductance just moving the coils with respect to rotating them.



The form below computes the main parameters for the two types of variometer described above. The self-

inductances are calculated using the formulas in [1], while the mutual inductances use the formulas from [2], with some minor corrections. These formulas agree very well with the **results of some electromagnetic simulations** I have done, see the page for details.

COILS DATA

Outer Coil

Diameter, d1 :	0.485	m
Length, l1 :	0.265	m
Turns, n1 :	62	

Inner Coil

Diameter, d2 :	0.33	m
Length, l2 :	0.24	m
Turns, n2 :	57	

Centres Distance, D : 1.0 m

Calculate

CALCULATED VALUES

Outer Coil Inductance, L1 :	1842	µH
Inner Coil Inductance, L2 :	896	µH

In a typical variometer the two coils are concentric (i.e. D=0) and the overall inductance is varied rotating the inner coil; in this case we have:

Mutual Inductance, M :	703	µH
Min Inductance Value, Lm :	1333	µH
Max Inductance Value, LM :	4144	µH

When the coils can not rotate but only move along their axis (coaxial coils), assuming a distance D between the two coils centres, we have:

Mutual Inductance, Md :	10.4	µH
Total Inductance, Ld :	2759	µH

The total inductance value for this case is computed assuming a positive mutual inductance (coils not rotated 180°).

References:

[1] R. Lundin, "**A Handbook Formula for the Inductance of a Single-Layer Circular Coil**," *Proc. IEEE*, vol. 73, no. 9, pp. 1428-1429, Sep. 1985.

[2] F.E. Terman, "**Radio Engineers' Handbook**," London, McGraw-Hill, 1st ed., Sep. 1950.

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Created: Fri Sep 08 00:01:05 CEST 2001
Last modified: Fri May 15 19:54:23 CEST 2015